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Air traffic control equipment at the Air ports of Russia and the East Bloc Countries in comparison with those of the ICAO

The following is a summarized presentation of the air traffic control equipment of Russia that is used in civil air transport. At the same time a comparison is made with equipment used by the ICAO (International Civil Aviation Organization), which serves the same purposes (Table 1). Essentially, the installations at the air ports are described which serve air traffic control in the approach zones or in bad weather.

Air traffic is arranged into air routes both in Russia and in the East Bloc Countries. Medium-wave radio beacons form the supporting structure of the MF-ground markings. Aloft, navigation is carried out by means of the ARK-5 automatic radiocompass. It has a frequency range of from 150 to 1,300 kilocycles in three bands and a sensitivity of from 10 to 12 microvolts.

1. The RSP-4 radar apparatus

The type DRL-4 search radar set, used at airports for ground flight control and observation of air space, is located next to the main takeoff and landing routes. The entire unit is portable and divided into three cars. In each there is a transmitter, a receiver, and an antenna array. The antenna has two separate reflectors trained at 180 degrees. One reflector sends out energy for a lower elevation; the other for a higher elevation angle. As a result, there is a radiation characteristic according to cosec^2

function in the vertical. In order to feed both antennas, the transmitter (λ-3 cm) is keyed in such a way that the power is directed to the feed leads of both reflectors periodically. The antenna rotates with 30 rpm. Acontrol apparatus with a cathode ray tube serves for observing the operation of the transmitter and receiver.

The viewing apparatus is located in the second car. Three units have been built in for the scanning operation. Each unit presents the radar image in a different range scale (6 - 20 - 35 km). There is no electrical gating of range rings. Range and azimuth can be ascertained with a mechanical reading device. The apparatus also operates without any fixed-echo erasing device (MTI). This is especially disadvantageous in close-in zone operations. Likewise, the sharpness of the image leaves much to be desired. A scale reproduction of the appropriate landscape is etched on a transparent cover over the cathode screen. In the same car, there is also a repeater viewing apparatus of the landing radar, so that the landing operations can also be observed. The video signal is transmitted on low frequency by cable. The approach guidance from the air route is carried out over USW radio communication on frequencies that have been fixed for the airport, until it is transferred to the landing radar. The divided arrangement of three viewing apparatus turns out to be disadvantageous to the observer. The power equipment is in the third car.

The observation and guidance of landing approaches takes place with the use of the PRL-4 radar apparatus. This apparatus is also mobile, and is located next to the instrument landing runway. The apparatus is set on a turntable so that it can also be turned to another direction. Behind a dielectric housing there is an antenna turned by electromechanical drive, for picking up the landing sector in azimuth and in elevation. The transmitter operates in a 3 cm area and is located in the same car with the receiver and two viewing apparatus. The viewing apparatus are arranged in a control panel style. The azimuth and elevation are reproduced on two separate radar screens. The location of aircraft approaching for a landing can be determined with the use of a rotatable scale. Range lines, approach flight base lines, and various glide routes (normally under 2.5 degrees) are gated electronically in the screen.

It is disadvantageous that the close range zone is also incapable of being reproduced on the screen, and for this reason, the final phase of the landing can barely be observed. Likewise, the sharpness of the blips could be better. Communications with planes aloft is carried out over USW, the transmitter of which is built directly to the car. For this purpose, there is a cone-disc antenna on the car roof.

The total radar unit, consisting of a search and landing radar, is called the type RSP-4.

2. The RD-1 pulse repeater for the SD-1 range finder, which is used on board planes.

The pulse repeater is the ground apparatus for the range finder. In it, the measuring pulses from the SD-1 aircraft apparatus are received, translated, and retransmitted. Some 45 planes can be served simultaneously by the RD-1. If more planes ask to be put on, the ground apparatus is cut off, and comes on again when the number of planes wanting to be put on is smaller. The apparatus is located in a tower-like building. An operating unit and a reserve unit are always necessary. When one unit goes out of order, the other is switched on automatically. The antennas are mounted on a special structure. The operating range is about f = 670 megacycles. It can be reached at a range of 150 km at an altitude of 4,000 m, and at a range of 60 or 70 km with an altitude of 1,000 m.

3. Beam and Bad weather landing Equipment.

The ground unit consists of:

The KRM-1 course beacon (new/type - KRM-2)

The GRM-1 glide beacon (new type - GRM-2)

The MRM-48 marker transmitter.

3.1 The KRM-1 (or KRM-2)

Its purpose is to guide aircraft during times of poor visibility from the base approach line to the runway. It is installed from

500 to 1,200 m from the end of the runway and operates on fixed frequencies. The opening angle of the antenna radiation is 70 degrees. For an altitude of 2,000 m, it has a range of 50 km, and at an altitude of 300 m, a range of 20 km.

The course beacon operates on the principle of phase comparison. The carrier wave transmitted from the transmitting central antenna is amplitude-modulated with a subcarrier of 10 kilocycles; however, the subcarrier isfrequency-modulated with 60 cycles. This oscillation produces the transmission phase. On both sides of the central antenna, there is still another beam antenna (Yagi antenna) installed vertically for the purpose of directing the beams. These send out beams in directional fields, which are amplitude-modulated with 60 cycles. Both modulation oscillations of the side antennas are opposed in phase to one another. During flight on course, both oscillations of the side antennas remain in equal proportion to the oscillation of the central antenna. When there is a deviation from course, the proportion changes in accordance with the direction of the deviation (right or left) and causes a deflection in the BSP-48 cross-pointer instrument on board the plane. Mechanical modulators (as with the older ILS units) are used for the purpose of modulation. The observation of the modulation oscillation is carried out with a cathode-beam oscillograph through Lissajous curve images on the screen.

In the KPM-2, the central antenna is also replaced by a directional antenna. The antenna array in this case consists of three analogous flat Yagi antennas. Each antenna has a dipole, a reflector, and 4 wave-directors. In the feed for the side antennas, a phase adjuster for guiding the position of the phase of the modulation oscillation has been built in.

Three similar KPK control apparatus control the beams. They control:

a. the transmitted power.

b. the course location and course width, and,

c. the phase location of the modulation oscillation inclusive.

An apparatus is located on the base approach line 114 m away from the antenna array in the direction of the runway. The second apparatus is located at the same distance, but at an angle of 5 degrees from the approach course. Both apparatus are supplied power and are remotely controlled from the course beacon. The data goes to an indicator in the service room of the beacon.

The diagram of the transmission lobes is directed vertically and has several maximum and serio points at various elevation angles.

3.2. The GRM-1 (or GRM-2) glide beacon.

It is used for laying out a sloped plane in the airspace, which an aircraft can follow vertically. The beacon can operate on either of three quartz-stabilized frequencies. The 90 cycle modulation oscillation of the transmission lobe is predominant over the glide path; the 150 cycle modulation is predominant under the glide path.

The air-borne receiver compares the modulation factor of both transmissions. The horizontal needle of the cross-pointer instrument indicates the position of the aircraft relative to the glide path. The location of the beacon is from 150 to 200 m away from the runway area, and about 150 m lateral to the runway. It is possible to set the glide angle between 2 and 3.5 degrees. The condition of the beacon is observed with the KIP-5 control and measuring apparatus. If there is a shift of about 0.2 degrees from the desired setting, the beacon shuts off automatically and sends a breakdown signal. The shutting off takes place with a delay of from 3 to 15 seconds. The control apparatus is a simple radio frequency receiver, the control antenna of which is installed on a mast 5 meters high and located 57 meters in front of the antenna array.

The glide beacon is also mobile. Its antenna array consists of two structural units. A two-stage antenna consisting of a dipole and a reflector serves as the "main" antenna. The "sub" antenna has two half-wave dipoles with angle reflectors. An adapter member serves to adjust the position of the phase ratios. As a protection from weather factors, all of the antenna elements are outfitted with a dielectric protective housing.

3.3. MRM-48 marker transmitter.

The antennas of the marker transmitter are located at a certain distance from the runway area, and send out a vertical transmission lobe into the airspaces. When a plane flies through this signal, the MRP-48 marker receiver indicates this, and gives an optical and accoustical signal. Sometimes 2 half-wave dipoles serve as transmitter antennas. These antennas are set on metal reflectors. The carrier wave (f = 75 mc) is amplitude-modulated with a certain code signal (table 2). A control receiver, which is located in the vicinity of the metal reflectors, keeps check on the operation of the marker transmitter, which is set up as an unmanned station.

The position of the previously described HF apparatus can be seen in figure 1.

4. ARP-1 automatic USW optical radio directional finder.

This station is also mobile. The receiver and the control-panel type viewing apparatus are located in a car. The receiver can be set on the prescribed USW approach frequency. The collapsible directional antenna is installed on the roof.

A cathode ray tube with about 30 cm diameter serves as the indicator apparatus. The tube is encompassed by a calibrated degree scale. The directional audio radio communications of the aircraft aloft appear in the form of a radial streak of light moving outward from the center point of the cathode ray screen. At the same time, the audio radio communications can also be heard. For this purpose, a loudspeaker is mounted over the cathode ray tube. A repeater viewing apparatus can be connected to the main viewing apparatus.

The directional communications with the aircraft is carried on by means of direct USW communications. Whenever it is possible, the direction finding car should be located at the extended center line of the runway. The installation of a repeater viewing apparatus in the indicator car of the search radar is provided for. Thus, there is the possibility for identifying the aircraft blips on the radar screen.

5. The take-off and Control car SKP.

The take-off and control car is located at the end of the runway that is in use. It is normal for this car to be outfitted with SW and USW transmitting and receiving apparatus.

The observation and guidance of all the movement of the airport originate from this car by means of audio radio communications. Moreover, all landing aircraft are advised from this car during their last phase. Also, the machines taking off receive their instruction s from there. This communication is carried out in a very primitive fashion. It has long been outmoded with regard to modern technology.

6. The control tower.

The central guidance of all air traffic control regulations come from the control tower. In comparison with Western airports, it is very simple and to a certain degree, is arranged and operated in an impracticable way.

In the control room facing the takeoff and landing runways, there are 3 control panel-type tables. On the left table is the panel for landing and airport lighting, the switch for lighting the pilot lamps belonging to the airport, the switches for the remote operation of the radio landing aids, and switches for the remote control of individual objects. Besides this, there are lamps for control of the radio beacon station, and a wall panel for accoustic control over a loudspeaker. Indicator apparatus check the condition of the course and glide routes of the radio beacons for landing in adverse weather. Five degrees of brightness of the landing lights can be set by means of a five-step regulator switch.

The middle part of the board holds the exchange panel for telephone communications, telephone apparatus, a control table for determining the required altitudes, microphone, a loudspeaker, indicator apparatus for determining wind velocity, wind direction, barometric pressure, and time. The communications with the aircraft are carried out by means of USW radio voice communications, which can take place in the control tower. On the right side of the table there are SW receivers.

The radio communications with the aircraft are recorded on magnetic tape. For this purpose, only a singl-track apparatus with a 12 cm tape winding capacity is available.

The control room is located in a tower-shaped building. It is enclosed in glass from all sides, but without anti-glare protection. Also there is no built-in climate unit (probably means heating or air-conditioning unit). In their room under the control room there are various types of control receivers, amplifiers, and relay frames for the remote control of the flight traffic control arrangements.

7. Lighting.

71. Landing lights.

Figure 2 illustrates the usual landing lights, which are at the airports now in use. The red color of the last three double-row arrangment of lights is charesteristic in this respect. The two-row arrangement was set up for safety purposes, to prevent aircraft that are just taking off from venturing through the lights on the landing base line, since up to the present, no lights with greater unbreakability and of smaller size have been available.

For new equipment, the so-called high-intensity landing lights are planned, as shown in figure 3. In essence, they are analogous to the layout of the "Calvert" system. The lights are only extended on the approach base line over the first crosspiece. The brightness of the lights can be regulated within 5 steps by remote control. These steps, as well as the on/off switches, are controlled from the tower.

7.2. Airport lighting.

The lighting of the landing and takeoff runways, the taxi runways, and buildings, is also deficient with regard to the current level of technology. In general, lights with non-directional beams and low intensity are used. The lights are controlled by means of transformers and ring cables. All of the switching and control takes place from the control tower.

TABLE I

Comparison of Russian and ICAO Equipment

RUSSIAN				ICAO			
Type	**Frequency**	**Modulation**	**Code**	**Type**	**Frequency**	**Modulation**	**Code**
Medium wave Beacon	150 kc 1300 kc			Medium wave Beacon			
Landing Control Beacons				ILS			
Course Beacon KPM-1-2	108.3 mc 110.3 mc	60 c phase comparison		Course Beacon	108 mc 112 mc	90 c, 150 c Degree of modulation comparison	1120 c
Glide Beacon GRM 1-2	332.6 mc 335 mc	90 c, 150 c modulation degree comparison		Glide Beacon	329 mc 335 mc	90 c, 150 c Degree of modulation comparison	
Marker Transmitter MRM-48	75 mc	400 c 1,300 c 3,000 c	6 P/S 2 S/S alternating 6 P/S 2 S/S	Marker Transmitter	75 mc	400 c 1,300 c 3,000 c	S-R P-S-R P-R
Range Finder SD-1 Pulse Regulator RD-1	$\lambda \sim$ 45 cm	Pulse		D.M.E.	Inquirer Signal 963.5 - 986 mc Answer Signal 1,188.5 - 1,211 mc	Pulse	
Landing Radar Unit							
Search Radar DRL-4	$\lambda \sim$ 3 cm			GCA Search Radar ASR	$\lambda \sim$ 10 cm	Pulse	
Landing Radar PRL-4	$\lambda \sim$ 3 cm			Landing Radar PAR	$\lambda \sim$ 3 cm	Pulse	

Type	Frequency	Modulation	Code	Type	Frequency	Modulation	Code
				VOR	112 mc 118 mc	30 C Phase comp.	
USW-Optical Radio Direction Finder	USW Radio Frequency	Speech		USW-Optical Radio Direction Finder	108 mc 136 mc radio frequency	Speech	

P = dot
S = dash
R = rhythm

TABLE II

COMPARISON OF BEACONS

	Russian System	ILS
Course Beacon		
Carrier freq-	108.3-108,7-109.1 109.3-109.5-110.3 mc	108 --- 112 mc
Modulation freq.	60 c	90 c (left) 150 c (right)
Range	altitude 2,000 m = 50 km altitude 300 m = 20 km	app. 40 km
Operating principle	phase comparison	modulation comparison
Beam width	0.6 - 1.0 degrees	
Opening angle	70°	
Output		200 w
Glide Beacon		
Carrier freq.	332.6-333.8-335 mc	328.6-335.4 mc
Modulation freq.	90 c (over) 150 c (under)	90 c (over) 150 c (under)
Range	1,500 m altitude - 25 km	about 16 km
Operating principle	modulation comparison	same
Opening angle	± 60°	
Angle of gradient	2 - 3.5 degrees	2 - 4 degrees
Beam width	0.35 degrees	
Power	40 w	25 w
Marker Transmitter		
Carrier freq.	75 mc	75 mc
Modulation freq.	400 c, 1300 c, 3,000 c	OM-400 c MM-1,300 c IM-3,000 c

CODE	6 dots per sec 2 dashes per sec 6 dots ~~and~~ per sec and 2 dashes per sec alternation	OM - Dash-rhythm MM - Dot-dash-rhythm BM - Dot-rhythm (Dot = $\frac{1}{12}$ of a second Dash 5/12 of a second Interim : 1/12 of a second
POWER	12 ± 3 w	5 w (carrier output)

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